

## RETROFIT OF AIR POLLUTION CONTROL EQUIPMENT AT THE SPSA/NAVY POWER PLANT

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### ABSTRACT

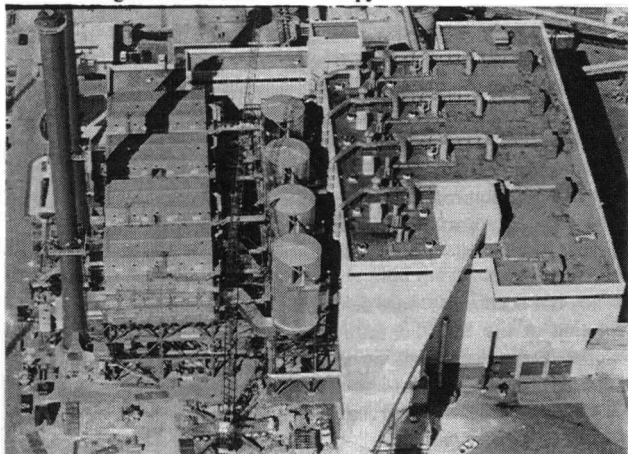
This paper will take the reader beyond the project management aspects of the described air pollution control retrofit at the SPSA/Navy power plant. It takes an inside look at the detailed issues of design, construction and operation of all equipment associated with this project. This paper will highlight many of the lessons learned and experience gained on the production side of the project.

Although requiring considerable extra effort by many of the parties involved, the project has thus far proven to be very successful and the air pollution control systems have operated well within the requirements of the contract documents and the EPA Emissions Guidelines.

### INTRODUCTION

The Southeastern Public Service Authority of Virginia (SPSA) operates a 2000 ton per day refuse derived fuel (RDF) and coal fired power plant, shown in fig. 1, for the US Navy at the Norfolk Naval Shipyard in Portsmouth, Virginia. SPSA responded to the 1991 EPA "Emission Guidelines", a 1992 state of Virginia consent agreement and the forthcoming federal regulations (40 CFR 60, Subpart Cb) by proceeding with an air pollution control equipment retrofit.

Figure 1: Norfolk Naval Shipyard Power Plant



### DESIGN

#### Plant Arrangement

The power plant consists of four stoker fired boiler trains designed to burn RDF(500 tons per day each) and/or coal on the grate. Each boiler produces 180,000 PPH of steam at 700 psig (47.6 atmospheres) and 750° F (399° C). The steam is used to drive three condensing steam turbines which produce electric power for parasitic load at the power plant and the shipyard with any excess sold to Virginia Power. Extraction steam is exported to the shipyard for building and ship-board heating. The flue gas from each boiler train passes through individual mechanical collectors and hot side electrostatic precipitators (ESP) for particulate collection. Flue gas leaves the economizer and enters the ESP at approximately 650° F (343° C). A regenerative Ljungstrom air heater recovers residual heat from the flue gas prior to exiting to the stack by way of the I.D. fan.

#### Design Considerations

Driven by the Emissions Guidelines and the consent agreement with the state of Virginia, SPSA contracted with HDR Engineering in 1991 to conduct a study to investigate available technologies for control of SO<sub>2</sub> and HCl as well as particulate, dioxin/furans and heavy metals. One of the first steps of the study was to contract for flue gas sampling and analysis to establish a baseline for current plant performance. This was necessary because no baseline for emissions other than opacity existed and from plant instrumentation it appeared that boiler performance had deteriorated from the original design. The study concluded that a Spray Dryer Absorber (SDA) and Fabric Filter (FF) would be required to meet Maximum Achievable Control Technology (MACT).

In order to establish the performance requirements for the SDA/FF retrofit, flue gas samples and measurements were taken downstream of the economizer. These measurements included flue gas flow rate, flue gas temperature and the emissions rates for acid gases, heavy metals, and dioxin/furans. From these tests, field instrumentation and original plant design data, the performance requirements for the SDA/FF retrofit were developed. Table 1 shows the original design conditions for the boilers and the design conditions for the SDA/FF retrofit.

Table 1: Flue Gas Conditions

Flue gas flow rate, lb/hr (kg/hr) <sup>1</sup>	366,000 (166,400)	411,600 (187,100)
Flue gas temperature, °F (°C) <sup>1</sup>	600 (316)	680 (360)

Note 1. - At boiler economizer outlet

The study also concluded that the Ljungstrom air heaters should be replaced with new recuperative tubular air heaters located ahead of the SDA. This recommendation was based upon a life cycle cost analysis which took into account the reduced lime consumption resulting from lower gas temperature, maintenance costs, capital costs of the new heater vs. the cost of upgrade and repair of the Ljungstrom heater, and differential fan horsepower consumption relative to pressure drop and heater leakage.

Due to the additional pressure drop imposed by the SDA/FF on the flue gas system, it was determined that the existing I.D. fans would require replacement since they were currently running at near maximum capacity. The new fan design conditions were calculated based on the measured flow rate and the pressure drop resulting from the addition of the new equipment. The calculations used conservative allowances for design conditions. Margins of 15% on flow and 32% on pressure were added to the calculated numbers.

Prior to issuing specifications for the procurement of the SDA/FF, SPSA and HDR visited several MWC facilities that were currently operating APC systems to provide the opportunity to meet with the operations personnel and see the systems and equipment in operation. The plant visits were selected to give a cross-section of vendors and differing technologies. It was determined that either rotary atomizer and two-fluid nozzle designs would be acceptable. Each had advantages and disadvantages, however, neither outweighed the other. One significant observation made at these plants was the lime preparation systems. Typically these systems consisted of the "slaker-in-a-can" approach which consists of a 12 foot diameter lime silo with the slakers, lime slurry tanks and pumps housed in the bottom of the silo. This arrangement is a common complaint of the operators as it is extremely difficult to maintain and clean. As result many of the systems were in poor condition.

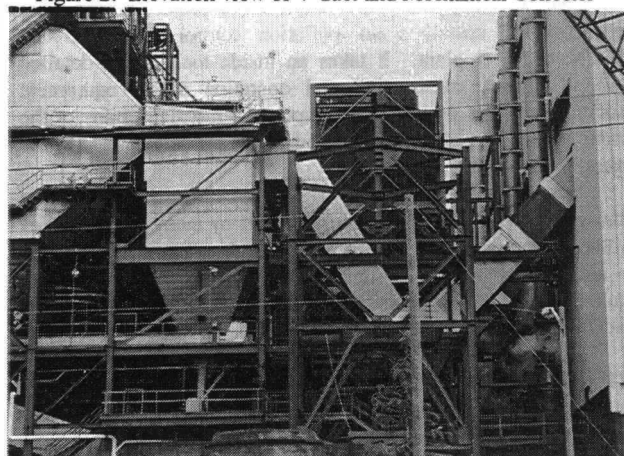
### SDA/FF Procurement

One of the first steps in the SDA/FF procurement process was to develop conceptual design drawings for the SPSA/Navy power plant. The site is very congested allowing little room for new equipment. Fortunately, the original plant was designed for the possible future addition of a scrubber. The space for the scrubber was located between the boiler house and the mechanical collector and was spanned by a "V" shaped flue gas duct. The arrangement of the V-duct and mechanical collector can be seen in fig. 2. Another problem is that the area underneath the V-duct is filled with ash conveyors, ductwork, cable tray and structural steel making the design and installation of support steel for the SDA very difficult. There were few places where columns could be located without interference. Also complicating the equipment layout is that rotary atomizer type SDA vessels are typically shorter and larger in

diameter that those of the two-fluid nozzle design. The space provided by the V-duct was not sufficient to install a rotary type vessel and the air heater in line between the boiler and ESP. It could, however, be located to the side of the boiler centerline, but this required locating another set of columns. Therefore, two conceptual plans were developed by HDR, one for each SDA design.

A conceptual design was also prepared for a lime preparation facility consisting of an engineered building housing the lime slurry preparation equipment. The silo is mounted on the roof steel with no internal columns through the building. Also, in separately enclosed areas within the building are rooms for the compressed air system equipment and the electrical, PLC and control interface equipment. The building layout provides for sufficient room for maintenance access and wash down capability to avoid the problems observed during the plant visits.

Figure 2: Elevation view of V-duct and Mechanical Collector



The lime preparation system was specified with margins in capacity, performance and redundancy to allow continued plant operation while providing for equipment maintenance outages. The lime silo has 7 days storage capacity assuming all four boilers operating. Two separate lime slurry preparation trains were required, each serving two boilers, with the capability to cross connect the systems in order to operate any boiler from either slurry train. Each slurry train consists of a paste type slaker sized for boiler operation, an eight hour storage tank at four boiler operation, and a 100% capacity slurry pump with an installed spare. Each train is powered from an independently fed motor control center (MCC). A cross tie between the MCC's allow for power supply in the event of a feeder failure. Two 100% capacity air compressors and air dryers were provided to supply the air required for fabric filter cleaning, atomization and control air. A separate PLC dedicated to the lime preparation facility was furnished with a hot stand-by processor installed..

Turn-key bid documents were developed by HDR for the supply and installation of the SDA/FF retrofit. Separate bid packages were developed for procurement of the air heaters, I.D. fans, piling, foundations and mechanical and electrical interface work. The air heaters and I.D. fans were purchased and turned over to the SDA/FF

contractor for installation. Due to construction crane weight/reach limitations, the air heaters were furnished with only 10% of the tubes installed to keep the lifting weight as low as possible. The remainder of the tubes were field installed under a separate contract.

Provisions for the future addition of Selective Non-catalytic Reduction (SNCR) for NO<sub>x</sub> control and carbon injection were provided in the event that it may be required in the future. Going into the procurement of the SDA/FF it was believed that the NO<sub>x</sub> and mercury levels were sufficiently low as not to require control equipment at this time.

Since the shipyard relies on the power plant for steam, it was not possible to shut down the entire power plant for this retrofit. The construction had to proceed on a unit by unit basis, taking only one unit out of service at a time. The bidders were allowed to propose their own construction and outage schedule in order encourage innovative ideas, however, evaluation credit was given to those bidders who proposed the shortest outage durations. Also, since the ESPs at the power plant were quite large, the contract documents allowed the bidders the option to utilize the existing ESP casing and structural steel to construct their fabric filter. Although this resulted in a considerable amount of reconstruction compared to modular filter units, it allowed for the use of the existing casing, hoppers, structure and ash handling system.

**Performance Requirements**

At the time of bidding and award of the SDA/FF contract, the EPA had yet to issue the new Emissions Guidelines for MWCs. In anticipation of more stringent MACT requirements under the Emissions Guidelines than in effect in 1991, the performance requirements for the SDA/FF retrofit were established as shown in Table 3. Due to the complexity and cost of the retrofit and the fact that SPSA was bound by the consent agreement to implement the retrofit prior to the issue of the EGs, a conservative approach was taken in developing the design conditions in the hope that any future changes in the regulations would not result in additional expensive modifications.

**Contract Award**

In May, 1993 the contract for the SDA/FF retrofit was awarded to a consortium between General Electric Environmental Services, Inc. and CNF Constructors. Mobilization was scheduled for October, 1993. GEESI's design approach included construction of SDA vessels and support steel prior any construction related unit outages. Their SDA design was a high speed rotary atomizer design using a flat belt drive for increasing atomizer wheel speed. They also decided to pursue the option of using the existing ESP casing for the new fabric filter by removing all internals and constructing eight filter compartments inside.

**CONSTRUCTION**

Construction activities were centered around the contract to provide and erect the SDA and fabric filter for each unit. This contract did not include foundations, utilities and the purchase of ID fans and tubular air heaters. A summary of contracts issued is shown in table 2. Three contracts were related to site work required for implementation of the SDA/FF portion as it was contracted. Several

other contracts were dovetailed into the major contract to complete the overall project as described in this paper.

Table 2: List of Contracts

Concrete Demolition	Phil R. Hobbs & Son
Piling	Prepakt
Mechanical/Electrical Utilities & Tie-ins	Hampton Roads Mechanical
Foundations, Pile Caps and Slabs	J.B. Denny
Air Heater	Zurn Industries
ID Fan	Buffalo Forge
Air Heater Tubing	Power Mechanical, Inc.
Demolition, Unit 4	Environmental Technologies, Inc.
Demolition Unit 1,2 and 3 and Fabric Filter/Ductwork Erection	Industrial Alloy Fabricators
Electrical, Structural, Insulation and Miscellaneous Mechanical	GEESI/CNF With Various Subcontractors
Concrete Restoration	The Kennedy Company

**Schedule**

The entire schedule was conceived based on completion of all construction activities prior to February of 1996. At no time during construction or startup were outages allowed on more than one combustion train.. Demolition related issues lead to some delay in the outage phase of unit 4 as discussed later in this paper. Some schedule was recovered for a completion expected at the end of March, 1996.

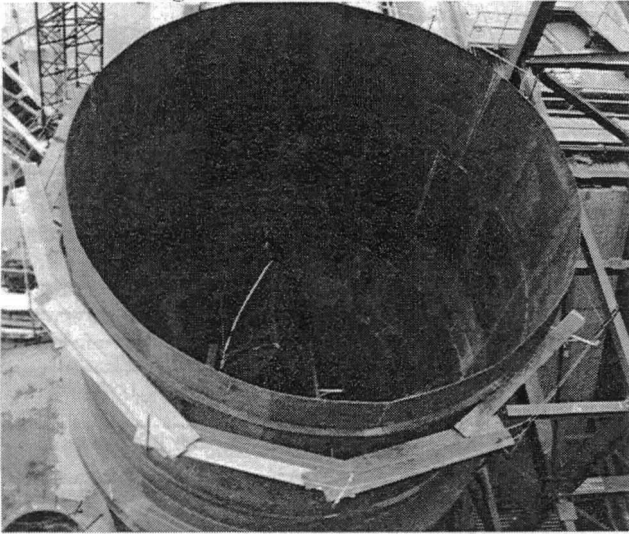
**Sitework**

The sitework phase included preparation of foundations and utilities for installation of the GEESI supplied equipment.

Figure 3: Mini-Pile Installation



Figure 4: Erection of SDA Vessel



Before installation of pile and foundations could be begun, the slab under the SDA area had to be removed. HDR designed the foundations based on the column location and loading diagrams provided by GEESI. The design required installation of 139 drilled in mini-piles, 33 driven piles and 24 auger cast piles. The minipiles were utilized in low head room areas and were drilled in using 5' lengths of steel pipe as shown in fig. 3. Installation of piles for the SDAs was complicated by the restricted headroom caused by the existing ductwork and cable tray and by high ground water. Also, many buried obstructions were hit in the process of installing the piles.

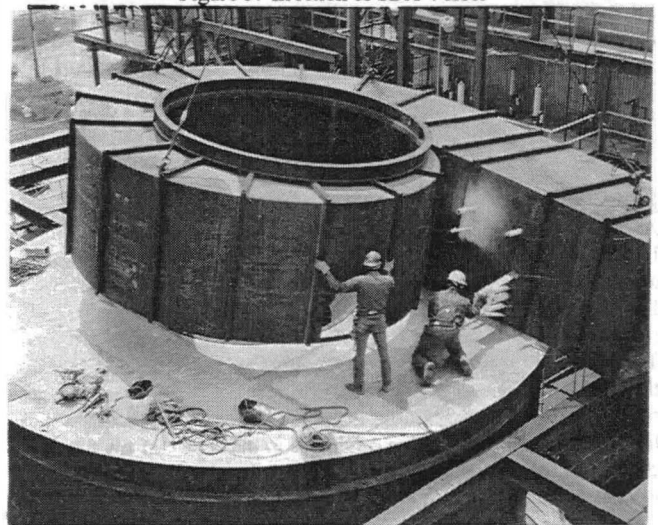
New foundations for the SDA and ductwork support columns were poured prior to the mobilization of CNF. Pile caps and anchor bolts were erected for 18 columns. These foundations were also designed by HDR with the loading information provided by GEESI. The overall GEESI design was based on converting the existing precipitator into a fabric filter by utilizing the shell, hoppers, ash handling system and associated structural steel. Therefore no foundations were required for the future fabric filter.

A separate Mechanical/Electrical construction contract was let for bringing site utilities to the locations agreed to in the contract. It was anticipated that for the duration of the construction activities, work scope items would be identified that would not be included in the base scope of the SDA/FF contract. For this reason the Mechanical/Electrical contract was written with special provisions to respond to extra scope items in a timely and cost effective manner. Three separate water supplies and compressed air were brought to the lime prep building for future tie in by GEESI/CNF. New switchgear breakers were installed and 480 volt feeders were run to bring the power supply to the new electrical room MCC's in the lime preparation building. The Mechanical/Electrical contractor mobilized in November of 1993 and had the utilities ready in May of 1994.

### **SDA/FF Erection**

Foundations were designed and installed and site utilities were run to the future locations while GEESI was completing design activities and drawing submittals for the prime contract. CNF constructors, as a consortium partner to GEESI, mobilized on January 10, 1994. Mobilization activities included erection of a 300 ton Demag crane. This crane would prove to be the nucleus of construction activities throughout the project. The crane is a Huffing type working tower with 138 feet (42m) of main boom and 158 feet (48m) of jib. Material began arriving for structural steel erection soon after CNF mobilized. SDA vessel fabrication also was an early activity in this project. Subassemblies were fabricated on the ground and assembled in place in the same sequence as the steel erection. The SDA erection is shown in various stages of progress in figures 4 and 5. The sequence began with unit 1, which was furthest away from the crane to units 2, 3 and 4. All SDA vessels were erected prior to the first unit outage.

Figure 5: Erection of SDA Vessel



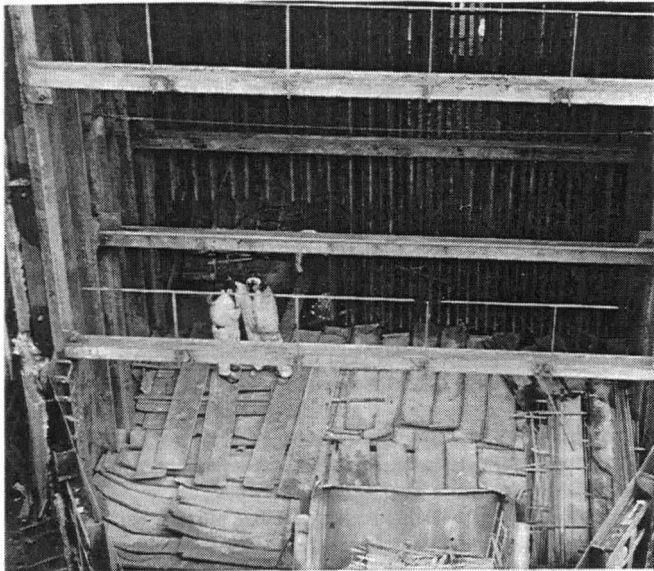
**Lime Prep Building.** Erection of the lime prep building began in the summer of 1994 and continued through the end of the same year. Specifications clearly detailed the layout of this building. The building is divided into three separate rooms. One half of the building houses lime preparation equipment, lime slurry pumps, dilution water pumps and storage tanks. Another room contains air compressors, dryers and an accumulator for the pulse jet system on the fabric filter. All of the electrical equipment and the PLC for these systems is housed in the remaining room.

**Demolition.** Demolition required for each unit included all flue gas ductwork from the boiler house wall to the precipitator inlet including a mechanical 'cyclone' separator. Also included in demolition was the Ljungstrom air heater and the ID fan for each combustion train. Reuse of the precipitator casing required a complete removal of all internal components in the precipitator. Figure 6 depicts ongoing removal of precipitator plates.



Operators of municipal waste combustors have, for some time, been cognizant of OSHA laws regarding safety measures for exposure of personnel to known quantities of lead and cadmium in fly ash. It was not clear, however, when this contract was negotiated, what the impact would be for construction work. During the time of the bidding and evaluation of the SDA/FF contract, similar OSHA laws for construction activities were published. GEESI/CNF made a claim for changed conditions based on the additional work and risk resulting from the potential personnel exposure to heavy metals contained in the fly ash in and on the ESP and ductwork to be demolished. Much time and effort was expended attempting to negotiate a change order to the contract which would allow GEESI/CNF to continue with the demolition activities as planned. It was HDR's opinion that a fair and reasonable change order could not be negotiated and it was agreed to remove the demolition scope of work from the GEESI/CNF contract.

Figure 6: Internal Precipitator Demolition



HDR prepared, bid and awarded the demolition scope of work which consisted of demolition of the existing flue gas ductwork, I.D. fan and the internals of the ESP as well as cleaning of the ESP casing believed to be suitable for reconstruction work without adherence to the OSHA regulations on lead and cadmium. The bid documents were issued to remediation contractors short listed based on their experience.

Demolition activities began on unit 4 (the first unit to be retrofitted) on October 3, 1994. These activities were allowed 35 days to complete removal and turnover a clean unit to GEESI/CNF for fabric filter reconstruction activities. The final activity for demolition was to high pressure wash the remaining precipitator casing to allow GEESI/CNF to proceed with the retrofit unencumbered by the OSHA regulations for lead and cadmium exposure. High pressure washing was completed on November 30, 1994.

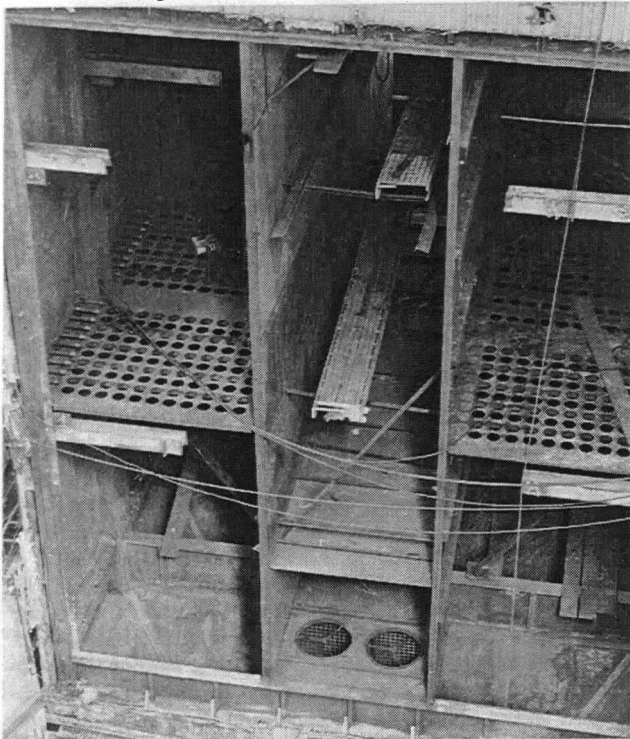
At this time, GEESI decided that they could not accept turnover of the ESP casing because they felt that it could not be adequately determined whether there remained any further potential for exposure to heavy metals. Consultation with certified industrial hygienists(CIH) resulted in the determination that the contractor who proceeds with the retrofit activities must still adhere to the OSHA lead and cadmium regulations, regardless of the actual surface cleanliness levels achieved. On December 2, 1994 a meeting was held with all concerned parties. It was decided to pursue removal of the ductwork and fabric filter erection from GEESI/CNF's scope of work. In a subsequent meeting, GEESI/CNF offered to keep the field erection in their scope for a contract value increase of \$2.75 million dollars plus any delay charges related to unit 4 demolition. HDR was unable to represent this change proposal as reasonable to SPSA and therefore it was agreed to remove the fabric filter/ductwork erection scope of work from the GEESI/CNF contract. This work scope had been originally subcontracted to Industrial Alloy Fabricators (IAF) by GEESI/CNF. An arrangement was made for SPSA to assume the contract with IAF to complete this work and prepared a change order for deletion of the scope from the GEESI/CNF contract

OSHA regulations for lead, cadmium and arsenic exposure were somewhat of an unknown for all of the parties involved. The regulations simply insure that personnel exposure is monitored and the proper personal protective equipment is employed to prevent exposure of individuals beyond the OSHA established personal exposure level (PEL). In the worst case, forced air respirators were required. This generally was the case when the bulk clean up inside duct work and the precipitator was being conducted and during removal of the precipitator plates and wires. Figure 6 shows some of the required demolition activities ongoing. It is most important to employ a CIH to monitor work areas and personnel to establish exposure levels. From the personnel and air monitoring data gathered, the CIH can make the determination that the requirements for respirators can be reduced. For example, demolition activities on the outside of the precipitator generally required only half face respirators. After demolition was complete and erection began, workers did not require respirators except when welding or cutting on formerly ash laden surfaces. In the end, the regulations were found to be fairly practical and could be followed without major impact on schedule and cost. The contractors who chose to deal with the regulations straight on had little trouble dealing with the situation. If a contractor chooses to remain ignorant of the regulations requirements because they believe it is in their best interest, difficulties will emerge for all involved.

Schedule delays on the first unit retrofitted (unit 4) resulted from poor performance by the original demolition contractor. Much of this delay was because the contractor was accustomed to remediation work but had little experience with heavy construction and demolition techniques. It was determined that this contractor did not have the ability to support the aggressive construction schedule for this project and his contract for the remaining units was terminated. For the remaining three units Industrial Alloy Fabricators assumed the demolition work scope along with the erection work already in their scope. Additional delays on the first unit were due to the time spent negotiating the changes to the

GEESI contract and due to the poor performance of the insulation subcontractor to the GEESI/CNF contract. Erection schedules were integrated and improved significantly on the remaining three units. Outage periods lasted 179, 127 and 105 days respectively for units 4, 3 and 2.

Figure 7: Field erection of Fabric Filter



### **Auxiliary Equipment**

The ID fans and motors were competitively bid and awarded to Buffalo Forge. This contract was for the supply of four double inlet fans with inlet damper control and the associated 900 hp two speed motors. The medium voltage motors replaced smaller 480v motors with variable speed drives. Installation of the fans, motors and starters was incorporated into the GEESI contract. This fan was designed such that the existing fan foundations and anchor bolts could be reused. Motor foundations were modified under a separate contract to accommodate the larger motors.

The new tubular air heaters were purchased from Zurn Industries. The air heater as designed had a total weight of 105,000 lb.. This weight greatly exceeded the capacity of the crane at the reach required for installation of some units. The weight of the air heater was limited to 30,000 lb. by factory-installing only enough tubes required for structural stability. Approximately 1800 tubes (90%) were installed in each air heater after the casing was set by IAF. The tubes were installed and rolled in place by means of a separate contract.

### **Final Work**

Upon completion of demolition of three units, another contract was let to pour new column piers and restore the grade level slab that was removed at the very beginning of this project. The Kennedy Company, a local contractor was awarded this work.

At the conclusion of the project, CNF is required to restore the site to its original condition, which includes replacing trees which were removed for lay down area and seeding the work area.

### **Start-up**

An oil fire was established in Unit 4 on March 23. The following day the fabric filter bags were precoated and a coal fire established. The SDA was put into operation and RDF fired on April 3, 1995. All four units followed a similar start-up sequence as follows:

1. Preheat fabric filter on oil fire. Bypass open - no flue gas through bags.
2. Shut off fuel.
3. Precoat bags with Neutralite.
4. Bring unit back up on oil and establish coal fire as quickly as possible.
5. Burn coal for 48 hours minimum with fabric filter on-line.
6. Establish pulse jet cleaning of fabric filter.
7. Put rotary atomizer in service.
8. Fire RDF.

The start-up sequence was reduced from 10 days on unit 4, to 3 days on unit 2.

## **OPERATIONS**

### **Pre-operational Planning**

SPSA Plant management began preparation for operation of the newly installed Spray Dryer Absorbers and Fabric Filters nearly a year before the equipment was ready for service. Since only a very small percentage of the Power Plant staff had had any experience with SDAs, fabric filters or lime prep equipment, management recognized the importance of pre-operational training. There are training requirements in the GEESI contract that were expected to provide the necessary pre-operation information needed to prepare the operations and maintenance staff. All training was intended to be based on the Operations and Maintenance Technical Manuals that GEESI was obligated to produce. The one year in advance preparation effort was not excessive.

### **Operations and Maintenance Technical Manuals**

The contract specifications called for documentation that pertained to the equipment supplied and installed on this particular job, rather than generic documentation or documentation for multiple similar pieces of equipment supplied by the same vendor. The contract specifications also required that the technical documentation provide sufficient data on each piece of equipment that a mechanic could use the data to determine if wear or other deterioration had made the part unsatisfactory for continued service. GEESI provided a manual from a previous job for review early in the project. It was obvious that this manual did not meet the minimum contract specifications.

Review of the first full submittal of technical manuals for this project found less than satisfactory work. This first submittal did not contain the detailed information required, and contained much information that did not apply to the SPSA Power Plant. The initial SPSA review of this submittal was brief, and the manuals were returned to GEESI with comments.

Since start-up was months away, there was only minimal concern by SPSA that the technical documentation would have any impact on operation. This was the case even though SPSA had made it clear from the beginning that completion of the training and approved operation and maintenance manuals were a pre-requisite for the Authority taking responsibility for operations and maintenance. This initial minimal concern grew quickly as SPSA's review of additional technical manual submittals found little improvement.

### **Training**

Eventually, start-up was scheduled, but training was not. Compromise by SPSA, and the development of a more clearly written operations manual by GEESI, broke the impasse and forty hours of training was presented to each of two groups of operators. Each member of the two classes was given a copy of this SDA/FF operations manual for use during the training, and for reference as operation began. This training was concluded with a written test of each student which gave Plant management a measure of both the success of the training and the relative knowledge of each student. The test questions were categorized based on job classification and area of responsibility. Supervisors are expected to be proficient in all areas covered by the training and test, while other operations shift personnel have less responsibility.

Operational responsibility was assumed by SPSA, but maintenance responsibility for all of the new equipment, including all of the lime preparation equipment, was initially left with GEESI. Refusal to accept maintenance responsibility was the lever needed to persuade GEESI to meet the contract specifications. Operation and maintenance manuals were finally approved in October, 1995. Additional maintenance training was provided to the mechanics, specifically on the rotary atomizer, and on some of the equipment in the lime preparation facility.

Completion of the operations and maintenance training and acceptance of the maintenance responsibilities for the new equipment put SPSA in full control of the system. Holding out for technical documentation an order of magnitude improved over the original submittals proved to be worth the effort. Plant management

should not hold operators and maintenance personnel responsible for operating and maintaining equipment until sufficient written instructions are available. Until we industrial consumers demand better, plant operators will continue to receive technical documentation that leaves a lot of room for improvement. This experience was not new to the SPSA staff, but our contractor was certainly surprised that we expected what we specified in our contract.

### **Co-lateral Support**

The single largest operational need that SPSA was responsible for providing was preparing for receiving and storing lime for use in the SDA. The lime supply contract was written, advertised and awarded in accordance with the technical specifications developed by HDR, and in accordance with the procurement specifications of the State of Virginia. This process went smoothly, and a supply contract was in place in December, 1994, well in advance of the need for lime.

Receiving and storing lime required a permit from the Virginia Department of Environmental Quality, (DEQ), Air Board, since there was a potential for lime dust being emitted into the air. SPSA's application was submitted and approved without difficulty. A member of the DEQ was present for the first lime delivery. He witnessed the operation of all of the equipment, and was satisfied that the design and operation met the requirements of the permit.

From the initial filling of the lime storage silo, there had been a constant problem with monitoring the quantity of lime on hand. The originally installed level alarms have proven to be inconsistent. In February 1996 this level system is scheduled to be replaced with strain gauges installed near the base of the silo. The readout from this system is expected to be far more accurate, and expected to remedy the problem of being able to ensure that sufficient lime is always on hand.

A second co-lateral operational responsibility was the procurement of spare parts to support operation of the equipment. The entire SDA/FF installation has a 15 month guarantee on all of the equipment. Even so, SPSA had the responsibility to have on hand spare parts, which could be replaced under the guarantee provisions, but which would allow immediate repairs. A recommended spare parts list for all of the equipment was provided by GEESI and their suppliers. This recommended list was reduced significantly to take advantage of the redundant equipment purchased under the construction contract. To date, there have been no lost operational hours awaiting repair parts.

Spare Parts procurement is not yet complete, but reasonably accurate projections indicate approximately \$300,000 will be spent to ensure that all material is not locally available is on hand to support SDA/FF Maintenance.

**Plant Operations with SDA/FF Air Pollution Control Equipment**

As with the start-up of any large mechanical project there are some rough spots, and the start-up of the first SDA/FF system on Boiler No. 4 at the SPSA/Navy Power Plant was no exception. The most significant issue that developed was not an operational problem, but an operational question that could have eventually affected system performance. The Fabric Filter is equipped with P-84 bags, chosen for its high temperature resistance.

The Plant's four boilers can fire stoker coal or RDF. Permit requirements do not currently require SO<sub>2</sub> control while firing low sulfur coal. During start-up, after the pre-coat of the fabric filter bags, and after firing RDF for several days, the Plant had reason to switch fuels back to coal. When coal was reintroduced, the Plant staff turned down the lime slurry injection, leaving sufficient dilution water to control SDA exit temperatures. This action caused concern with GEESI, since they feared blinding the bags with the very small particulate size produced under the "no lime injection" operations.

Since the question of whether the coal with no lime operation could cause a bag problem could not be immediately answered, the Plant's staff were instructed to operate at a minimum lime injection while firing coal. As time progressed, the operating staff questioned the fact that the No. 4 fabric filter was in a constant state of pulse jet cleaning. This situation and the higher than expected pressure drop across the baghouse added credibility to the theory that the bags had been damaged during the coal firing without lime slurry injection.

This operational restriction was not part of the vendor training package, and SPSA took the position that any problems were GEESI problems under the guarantee provisions of the contract. GEESI had several bags removed from the No. 4 Fabric Filter and sent to the manufacturer for analysis. The results of this analysis found no deterioration in the bags. As a result, further investigation into the high pressure drop is ongoing.

**SDA/FF Performance**

Entropy, Incorporated was contracted by competitive bid to perform all of the air emission testing at the SPSA Power Plant through the performance and acceptance testing of the four new SDA/FF installations. To date, initial acceptance testing has been conducted on three of the four units, and in each case the testing was performed approximately 30 days after the unit was brought on line. Final acceptance testing will be conducted after a minimum of 12 months of operation on each unit.

Test results on the first two units found totally satisfactory results, as summarized in Table 3. The emission of highest concern was dioxin/furans. Test results on all of the tested units to date have found dioxin/furan levels well below the lowest limits required in the consent agreement of 60 ng/dscm (30 ng/dscm required by the Emissions Guidelines). Needless to say, the test results have been very gratifying to the Authority.

Table 3: Design Requirements and Test Results

Sulfur Dioxide, ppm <sub>dv</sub>	30 or 85% red.	25
Hydrogen Chloride, ppm <sub>dv</sub>	25 or 95% red.	2.0
Particulate, gr/dscf (g/dscm)	0.015	0.00076
Dioxin/furan, ng/dscm	30	3.95
Opacity, pct	10%	2-3%

**Lime Consumption**

The single largest operating expense for this equipment is the procurement of lime. The contract with GEESI established a guarantee limit for lime consumption. The guaranteed value for firing RDF at 100% MCR was 386 lb/hr (175kg/hr). The guarantee value was corrected for load and SDA inlet temperature. Testing on operational units have shown average consumption of 257 lb/hr (117kg/hr).

**CONCLUSION**

Prior to the SDA/FF retrofit, the continued operation of the SPSA/Navy Power Plant on RDF was placed in jeopardy by its poor performance during the annual dioxin/furan tests. The Virginia Department of Environmental Quality and the plant's owner, the Navy, entered into a consent agreement that required compliance with dioxin/furan emission limits of 60 ng/dscm total at the stack.

SPSA responded with the \$31 million dollar SDA/FF retrofit project that appears to have exceeded the demands of the consent agreement, and at the same time implemented a system which improves upon similar equipment observed at other plants. Maintenance and operation costs have been minimized by a thorough and deliberate planning process.

The many lessons learned include:

- Develop detailed specifications on layout of auxiliary equipment.
- Conduct detailed review of vendor drawing submittals to minimize construction issues.
- Establish payment milestones for O&M manual approval to insure control of the end product.
- Establish alternate means of contracting extra work.
- Be willing to educate contractors on OSHA exposure regulations. Choose contractors who have the experience and resources to do the mechanical work. The OSHA regulations, like confined space entry rules, can be learned and followed by any contractor who is willing to do so.

Despite the many challenges, difficulties and setbacks, SPSA and HDR working closely with the contractors and with the contractor's cooperation will bring this project in under budget and slightly behind the original schedule. Even though the project is approximately two months behind schedule, it has still met the terms of the agreement with the state of Virginia. Performance of the SDA/FF system has exceeded all of the contract requirements.